WHAT IS CLAIMED IS:

1.        A method for matching a two dimensional image to one of a plurality of three dimensional candidate models, the method comprising the steps of:

determining the position and orientation of the two dimensional image;

for each three dimensional candidate model, computing a histogram-like table having a computed brightness coefficient for each surface normal of the three dimensional candidate model based on the corresponding value in the two dimensional image, each brightness coefficient depending only on the corresponding surface normal;

successively rendering each three dimensional candidate model in the determined position and orientation using the surface normals in conjunction with the corresponding computed brightness histogram-like table; and

comparing the two dimensional image with each of the rendered three dimensional candidate models.

2.        The method of claim 1, further comprising the steps of determining if the two dimensional image matches one of the plurality of three dimensional models if the comparison between the two dimensional image and the rendered three dimensional model is within a predetermined allowable error.

3.        The method of claim 1, wherein the comparison step results in a ranking for each of the rendered three dimensional models which indicates the likelihood that the corresponding three dimensional model matches the two dimensional image.

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4. The method of claim 3, further comprising the step of choosing the three dimensional model corresponding to the rendered three dimensional model having the highest ranking as the three dimensional model which matches the two dimensional image.

5. The method of claim 1, further comprising the step of reading the three dimensional models from a database containing the plurality of three dimensional models.

6. The method of claim 1, wherein the comparing step is done simultaneously with the rendering step for each rendered three dimensional model.

7. The method of claim 1, wherein the computing step sets a minimum threshold of reflectance to be used in the computation of the histogram-like table.

8. The method of claim 1, wherein the computing step sets a minimum and/or maximum threshold of intensity to be used in the computation of the histogram-like table.

9. The method of claim 1, wherein the two dimensional image is a color image and wherein the a brightness coefficient is computed for each color component of the color image.

10. The method of claim 1, further comprising the step of smoothing the lightsphere histogram-like table to improve the rendering of each three dimensional model and the performance of the method.

11. The method of claim 10, wherein the smoothing step is done by a convolution with a small box function or other small

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3    smoothing kernel.

1    12.        A method for matching a two dimensional image to one of
2    a plurality of three dimensional candidate models, the method
3    comprising the steps of:

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5        determining the position and orientation of the two
6    dimensional image;

7

8        for each three dimensional candidate model, computing a
9    histogram-like table having a computed brightness coefficient for
10   each surface normal of the three dimensional candidate model
11   based on the corresponding value in the two dimensional image,
12   each brightness coefficient depending only on the corresponding
13   surface normal;

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15       computing the variance of the brightness coefficients
16   that are used to create each bucket of the histogram-like table,
17   a bucket being a set of similar normal values that are lumped
18   together to form a single argument value in the histogram-like
19   table;

20

21       computing the sum of the variances of the histogram-
22   like table buckets; and

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24       ranking the three dimensional candidate models using
25   its computed sum as an error function, the ranking indicating the
26   likelihood that the corresponding three dimensional model matches
27   the two dimensional image.

1    13.        The method of claim 12, further comprising the step of
2    choosing the three dimensional model corresponding to the three
3    dimensional model having the highest ranking as the three
4    dimensional model which matches the two dimensional image.

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14.    The method of claim 12, further comprising the step of reading the three dimensional models from a database containing the plurality of three dimensional models.

15.    The method of claim 12, wherein the computing step sets a minimum threshold of reflectance to be used in the computation of the histogram-like table.

16.    The method of claim 12, wherein the computing step sets a minimum and/or maximum threshold of intensity to be used in the computation of the histogram-like table.

17.    The method of claim 12, wherein the two dimensional image is a color image and wherein the a brightness coefficient is computed for each color component of the color image.

18.    The method of claim 12, wherein the sum of the variances are weighted by the number of samples in each bucket.

19.    A method for matching a two dimensional image to one of a plurality of three dimensional candidate models, the method comprising the steps of:

    determining the position and orientation of an object giving rise to the two dimensional image;

    computing a representation of lighting effects that allows the lighting that gave rise to the two dimensional image to be used to render a realistic image of a three dimensional candidate model;

    successively rendering each three dimensional candidate model in the determined position and orientation using the

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15 surface normals in conjunction with the corresponding computed
16 representation of lighting effects; and

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18        comparing the two dimensional image with each of the
19 rendered three dimensional candidate models.


1  20.        A method for matching a two dimensional image to one of
2  a plurality of three dimensional candidate models, the method
3  comprising the steps of:

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5        determining the position and orientation of an object
6  giving rise to the two dimensional image;

7

8        computing a representation of lighting effects based on
9  the plurality of three dimensional candidate models and the two
10 dimensional image that allows evaluation of the likelihood that a
11 particular three dimensional candidate model gave rise to a
12 particular two dimensional image; and

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14        choosing the most likely three dimensional candidate
15 model to have generated the query based on the computed
16 representation of lighting effects.


21.        A computer program product embodied in a computer-
2  readable medium for matching a two dimensional image to one of a
3  plurality of three dimensional candidate models stored in a
4  database, the computer program product comprising:

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6        computer readable program code means for determining
7  the position and orientation of the two dimensional image;

8

9        computer readable program code means for computing a
10 histogram-like table each three dimensional candidate model,
11 having a computed brightness coefficient for each surface normal

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12 of the three dimensional candidate model based on the
13 corresponding value in the two dimensional image, each brightness
14 coefficient depending only on the corresponding surface normal;

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16 computer readable program code means for successively
17 rendering each three dimensional candidate model in the
18 determined position and orientation using the surface normals in
19 conjunction with the corresponding computed brightness histogram-
20 like table; and

21

22 computer readable program code means for comparing the
23 two dimensional image with each of the rendered three dimensional
24 candidate models.

22. A program storage device readable by machine, tangibly
embodying a program of instructions executable by the machine to
perform method steps for matching a two dimensional image to one
of a plurality of three dimensional candidate models, the method
comprising the steps of:

determining the position and orientation of the two
dimensional image;

for each three dimensional candidate model, computing a
11 histogram-like table having a computed brightness coefficient for
12 each surface normal of the three dimensional candidate model
13 based on the corresponding value in the two dimensional image,
14 each brightness coefficient depending only on the corresponding
15 surface normal;

16

17 successively rendering each three dimensional candidate
18 model in the determined position and orientation using the
19 surface normals in conjunction with the corresponding computed
20 brightness histogram-like table; and

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21        comparing the two dimensional image with each of the

22    rendered three dimensional candidate models.

1    23.      A computer program product embodied in a computer-

2    readable medium for matching a two dimensional image to one of a

3    plurality of three dimensional candidate models stored in a

4    database, the computer program product comprising:

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6        computer readable program code means for determining

7    the position and orientation of the two dimensional image;

8

9        computer readable program code means for computing a

10    histogram-like table for each three dimensional candidate model,

11    having a computed brightness coefficient for each surface normal

12    of the three dimensional candidate model based on the

13    corresponding value in the two dimensional image, each brightness

14    coefficient depending only on the corresponding surface normal;

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16        computer readable program code means for computing the

17    variance of the brightness coefficients that are used to create

18    each bucket of the histogram-like table, a bucket being a set of

19    similar normal values that are lumped together to form a single

20    argument value in the histogram-like table;

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22        computer readable program code means for computing the

23    sum of the variances of the histogram-like table buckets; and

24

25        computer readable program code means for ranking the

26    three dimensional candidate models using its computed sum as an

27    error function, the ranking indicating the likelihood that the

28    corresponding three dimensional model matches the two dimensional

29    image.

1    24.      A program storage device readable by machine, tangibly

2 embodying a program of instructions executable by the machine to
3 perform method steps for matching a two dimensional image to one
4 of a plurality of three dimensional candidate models, the method
5 comprising the steps of:

6

7     determining the position and orientation of the two
8 dimensional image;

9

10     for each three dimensional candidate model, computing a
11 histogram-like table having a computed brightness coefficient for
12 each surface normal of the three dimensional candidate model
13 based on the corresponding value in the two dimensional image,
14 each brightness coefficient depending only on the corresponding
15 surface normal;

16

17     computing the variance of the brightness coefficients
18 that are used to create each bucket of the histogram-like table,
19 a bucket being a set of similar normal values that are lumped
20 together to form a single argument value in the histogram-like
21 table;

22

23     computing the sum of the variances of the histogram-
24 like table buckets; and

25

26     ranking the three dimensional models using its computed
27 sum as an error function, the ranking indicating the likelihood
28 that the corresponding three dimensional candidate model matches
29 the two dimensional image.

1 25.     A computer program product embodied in a computer-
2 readable medium for matching a two dimensional image to one of a
3 plurality of three dimensional candidate models stored in a
4 database, the computer program product comprising:
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6          computer readable program code means for determining
7     the position and orientation of an object giving rise to the two
8     dimensional image;

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10         computer readable program code means for computing a
11    representation of lighting effects that allows the lighting that
12    gave rise to the two dimensional image to be used to render a
13    realistic image of a three dimensional candidate model;

14

15         computer readable program code means for successively
16    rendering each three dimensional candidate model in the
17    determined position and orientation using the surface normals in
18    conjunction with the corresponding computed representation of
19    lighting effects; and

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21         computer readable program code means for comparing the
22    two dimensional image with each of the rendered three dimensional
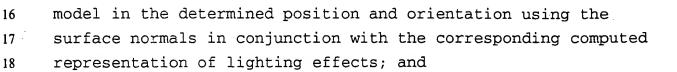23    candidate models.

26.        A program storage device readable by machine, tangibly
embodying a program of instructions executable by the machine to
perform method steps for matching a two dimensional image to one
of a plurality of three dimensional candidate models, the method
comprising the steps of:

7          determining the position and orientation of an object
8     giving rise to the two dimensional image;

9

10         computing a representation of lighting effects that
11    allows the lighting that gave rise to the two dimensional image
12    to be used to render a realistic image of a three dimensional
13    candidate model;

14

15         successively rendering each three dimensional candidate

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16  model in the determined position and orientation using the
17  surface normals in conjunction with the corresponding computed
18  representation of lighting effects; and

19

20  comparing the two dimensional image with each of the
21  rendered three dimensional candidate models.


1  27.      A computer program product embodied in a computer-
2  readable medium for matching a two dimensional image to one of a
3  plurality of three dimensional candidate models stored in a
4  database, the computer program product comprising:

5

6  computer readable program code means for determining
7  the position and orientation of an object giving rise to the two
8  dimensional image;

9

10  computer readable program code means for computing a
11  representation of lighting effects based on the plurality of
12  three dimensional candidate models and the two dimensional image
13  that allows evaluation of the likelihood that a particular three
14  dimensional candidate model gave rise to a particular two
15  dimensional image; and

16

17  computer readable program code means for choosing the
18  most likely three dimensional candidate model to have generated
19  the query based on the computed representation of lighting
20  effects.

1  28.      A program storage device readable by machine, tangibly
2  embodying a program of instructions executable by the machine to
3  perform method steps for matching a two dimensional image to one
4  of a plurality of three dimensional candidate models, the method
5  comprising the steps of:

6

7        determining the position and orientation of an object

8  giving rise to the two dimensional image;

9

10        computer readable program code means for computing a

11  representation of lighting effects based on the plurality of

12  three dimensional candidate models and the two dimensional image

13  that allows evaluation of the likelihood that a particular three

14  dimensional candidate model gave rise to a particular two

15  dimensional image; and

16

17        computer readable program code means for choosing the

18  most likely three dimensional candidate model to have generated

19  the query based on the computed representation of lighting

20  effects.